Distinguishing Between Apollo 14 High-Alumina (HA) Basalts and Impact-Generated Olivine Vitrophyres (OVs)

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Abstract. The objective of this work is to distinguish between the petrographically similar Apollo 14 (A-14) impact melt-generated olivine vitrophyres (OVs) and pristine, High-Alumina mare basalts (Groups A, B, C[1]). We use textural and chemical analyses of vitrophyre and basalt clasts from Apollo 14 breccia 14321 to provide information about the melts from which the olivines crystallized. In addition, we compare the analyses with various basalt groups (vitrophyric, olivine, ilmenite, and pigeonite) from the nearby Apollo 12 (A-12) site.

Major and trace element analyses were conducted on olivines from the A-12 and A-14 basalts and the A-14 impact melts. Mn abundances obtained by electron microprobe (at Washington University, St. Louis) were used as the internal standard while NIST SRM 610 glass was employed as the external standard to acquire trace elements using laser-ablation inductively coupled plasma mass spectrometry at the University of Notre Dame.

While olivine compositions from the A-14 OVs and basalts show some similarities, there are distinct differences. For example, the olivines in A-14 OVs are more Fo-rich compared to the A-14 and A-12 mare basalts. In addition, basaltic olivines typically have higher V, Co, Sc, Cr, and Mn and lower Ti and Y abundances than those in the OVs. Furthermore, the A-12 basalts contain the highest abundances of Cr, Co, and Ni among all olivines analyzed.

Crystal size distributions (CSDs) can be used as a guide for compositional analyses and to quantitatively investigate igneous processes. Basaltic olivine CSDs have lower slopes than their A-14 OV counterparts. Additionally, each basalt group displays a unique olivine CSD shape/slope as previously shown with regards to plagioclase[2]. These differences indicate that 14321 impact melts and basalts undergo distinctly different crystallization conditions. Given their distinct mineral chemistry, this provides further evidence that the HA basalts are not impact melts as has been suggested by some[3]. Additionally, the similar slope of Apollo 12 sample 12004 with the A-14 basaltic samples suggests there may be a general trend for olivine-rich basalts.

Mineral chemistry and textural analyses show the A-14 OVs are distinct from pristine A-12 and A-14 mare basalts. We conclude that mineral chemistry and textural analysis can be used to distinguish impact-generated melts from pristine basalts. Such an approach is relatively non-destructive relative to the time-consuming and destructive traditional method of highly siderophile elements determinations.

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